INDOOR AIR QUALITY ASSESSMENT

Auburn High School
99 Auburn Street
Auburn, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Principal Jeffery Theodoss, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at Auburn High School.

On December 20, 2001, a visit was made to this school by Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment. Mr. Feeney was accompanied by Cory Holmes, Environmental Analyst, and Suzan Donahue, Research Assistant, both of whom work in the ER/IAQ program.

The original school building is a two-story brick structure with a basement built in 1935. Additions were added in 1953 and in 1973. The school contains general classrooms, science rooms, art room, a woodshop, small engine/print shop, a gymnasium, a music/chorus room, media center, cafeteria and office space. A classroom located in the basement level is also used to house pre-school students.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

This school has a student population of approximately 600 and a staff of approximately 60. Tests were taken during normal operations at the school and results appear in Tables 1-7.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in forty-two of sixty areas surveyed, indicating an overall ventilation problem in the school. It should be noted that several classrooms had open windows during the assessment, which can greatly reduce carbon dioxide levels.

Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Picture 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit (see Figure 1). Fresh air and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Univents were found deactivated in a number of classrooms (see Tables).

Univents in the original building, as well as in the 1953 and 1973 wings, appear to be original equipment, which would make them approximately thirty to fifty years old. None of the univents appeared to be operable in the original building. A number of univents in the 1953 and 1973 wings were deactivated or not operating. Univents in these wings do not run continuously but are activated by thermostats once room temperatures drop below a set level. When the room temperature exceeds the thermostat setting, univents deactivate. Without mechanical ventilation running continuously, fresh air cannot be introduced into classrooms on a consistent basis.

Obstructions to airflow, such as objects stored on or in front of univents, were also observed in a number of classrooms. In order for univents to function as designed, univents must be activated and remain free of obstructions.

The mechanical exhaust ventilation system consists of ceiling and wall-mounted exhaust vents, some of which are located in ungrated holes located at floor level. These vents are connected to exhaust fans on the roof (see Picture 2). An examination of these exhaust vents found more than half of the exhaust vent motors either deactivated or barely drawing air (see Table 8). Exhaust vents on the side of the building were also found deactivated (see Picture 3). Bird's nests were observed inside these vents which appear to service the audiovisual room, auditorium and TV studio. Tables, chairs, boxes and other items obstructed a number of exhaust vents. Some exhaust vents are equipped with pull chains that control a flue that adjusts airflow out of the ventilation shaft. A number of these control mechanisms (i.e., pull chains and flues) were missing or not operable. A weak draw of air at best was detected in classrooms throughout the building (see Tables), which can indicate that the exhaust ventilation was turned off, rooftop motors were not functioning, or control mechanisms such as flues were shut.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches (see Appendix I).

Temperature measurements ranged from 66^{o} F to 77^{o} F, which were below the BEHA recommended comfort range in a number of areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. A number of temperature control complaints were expressed to BEHA staff. It is difficult to control temperature and maintain comfort in a building without operating the HVAC equipment as designed. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 27 to 41 percent, which was below the BEHA recommended comfort range in most areas. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Of note is that relative humidity measured indoors exceeded outdoor measurements (range +1-11 percent). The increase in relative humidity can indicate that the exhaust system is not operating sufficiently to remove normal indoor air pollutants (e.g., water vapor from respiration).

Moisture removal is important since the sensation of heat conditions increases as relative humidity increases. As indoor temperatures rise, the addition of more relative humidity will make occupants feel hotter. If moisture is removed, the comfort of the individuals is increased. Removal of moisture from the air, however, can have some negative effects. As previously mentioned, the sensation of dryness and irritation is common in a low relative humidity environment. Humidity is more difficult to control during the winter heating season.

This assessment occurred on a day with periods of heavy precipitation. With the combination of inactive ventilation systems and open exterior doors and windows, relative humidity levels can become elevated indoors. While temperature is mainly a comfort issue, relative humidity in excess of 70% can provide an environment for mold and fungal growth (ASHRAE, 1989).

Microbial/Moisture Concerns

A number of interior areas of the building had signs of water damage. Water-damaged wall/ceiling plaster was noted throughout the building (see Picture 4). Water-damaged wall plaster was frequently noted above windows. Water-damaged ceiling tiles were noted in a number of classrooms, which are evidence of historic roof or plumbing leaks. Water-damaged building materials can serve as mold growth media, and should be replaced after a water leak is discovered.

Several classrooms contained a number of plants. Plant soil, standing water and drip pans can be a potential source of mold growth. Drip pans should be inspected periodically for mold growth and over-watering should be avoided. Plants should also be located away from univents to prevent aerosolization of dirt, pollen or mold.

Classroom 108 contained several fish tanks with algae growth. Aquariums should be properly maintained to prevent microbial/algae growth, which can emit unpleasant odors.

Along the perimeter of the building, shrubbery and flowering plants were noted in close proximity to univent fresh air intakes or in contact with exterior walls (see Picture

5). Shrubbery and flowering plants can be a source of mold and pollen and should be placed and/or maintained to ensure that fresh air intakes remain clear of obstructions to prevent the entrainment of dirt, pollen or mold into the building.

Other Concerns

Several other conditions were noted during the assessment which can effect indoor air quality.

Chemistry Laboratories

Experiments in science labs that produced significant smoke were noted. Exhaust fans to remove smoke and other odors are installed in science classroom windows (see Picture 6). These fans are reportedly not used because they produce a loud noise when activated. Fans should be activated prior to beginning smoke/odor-producing experiments.

Science Wing Chemical Storage

The chemical storeroom had the following conditions:

1. The exhaust vent fan was not operating at the time of the assessment. Exhaust ventilation is necessary to remove off-gassing from chemicals in storage from the interior of the building.
2. Of note is the condition of the flameproof cabinet in the chemical storeroom. A selection of flammable materials (see Table 9) were stored within this cabinet as well as in the storeroom, outside of the cabinet. The bung-hole covers were removed from the flameproof cabinets (see Picture 7). The National Fire Prevention Association (NFPA) does not require venting in flammable storage

cabinets, however, if venting is done, it must be vented directly outdoors and in a manner not to compromise the specific performance of the cabinet (NFPA, 1996). With this breach, it would not be expected that this cabinet would perform as designed in the case of a fire.

3. An unlabelled container of elemental mercury, in a quantity estimated to weigh 10 lbs., was stored on an open shelf (see Picture 8).
4. Two corroded containers of phosphorous were stored on an open shelf (see Picture 9).
5. A box that appears to be chemically damaged exists on top of a cabinet (see Picture 10).
6. A container of carbon tetrachloride exists on a cabinet. Plastic sheeting on top of the cabinet, in contact with this container, is adhered to the container, indicating possible off-gassing interaction with the plastic (see Picture 11).
7. Chemicals in the storeroom are stored on shelves without any barriers to prevent bottles from falling.
8. A container of leaking phenylhydrazine base was found in one of the flameproof cabinets (see Picture 12). Phenylhydrazine is considered an extremely hazardous material that requires special handling.
9. Chemicals in several classrooms are labeled with the chemical formula instead of the chemical name.
10. One bottle was stopped with a stopper made of cork material. Cork is not an appropriate material for sealing hazardous materials.

It is highly recommended that a thorough inventory of chemicals in the science department be done to assess chemical storage.

Wood Shop

A number of materials are also stored in a plain metal cabinet in the wood shop (see Picture 13). These products are flammable and should be stored in a cabinet which meets the criteria set forth by the NFPA (NFPA, 1996). The woodshop has local exhaust ventilation for wood cutting/sanding machines. A wood dust collector exists in this room. This wood dust collector is not ducted to the outdoors, but is allowed to exhaust into the room (see Picture 14). Since the wood dust collector is not designed to filter small diameter particles, the use of this machine without ducting outdoors may aerosolize wood dust to allow it to be more readily inhaled. Excessive amounts of wood dust on flat surfaces indicate that wood dust aerosolization is occurring. Wood dust can be irritating to the eyes, nose, throat and respiratory system. A ceiling-mounted fan heater also exists in this room. Under certain conditions, wood dust is a fire hazard.

Print Shop

The print shop has a printing machine that does not have a dedicated local exhaust ventilation system. An exhaust hood exists in the corner of this area, which was originally used for venting metalworking in this room (see Picture 15). Inside the print shop are a number of printers that use volatile organic compound (VOC) containing materials. No local dedicated exhaust ventilation exists for any of the printers. Inks, washes and hand cleaners used in printing can contain VOCs, which can be irritating to the eyes, nose, throat and respiratory system. Products containing VOCs must be used with adequate exhaust ventilation to prevent exposure.

Also of concern is the connection of a flameproof cabinet to a duct on the exterior wall of the building (see Pictures 16 and 16A). As previously mentioned, the NFPA recommends that flammable storage cabinets be constructed in a manner to prevent fire from coming in contact with stored chemicals. In addition, it is recommended that if a flammables storage cabinet is connected to a vent system, the vent system should not be constructed in a manner to provide an oxygen source to the interior of the cabinet. It must be vented directly outdoors and in a manner not to compromise the specific performance of the cabinet (NFPA, 1996).

Bird Nesting

Bird wastes were observed inside exhaust vents along the west exterior wall of the building (see Picture 17). Under these conditions, it is possible for molds and allergenic materials associated with bird wastes and feathers to be entrained by the air intake and distributed into the classroom via the univent. Bird wastes in a building raise three concerns: 1) diseases that may be caused by exposure to bird wastes, 2) the need for clean-up of bird waste and 3) appropriate disinfection.

Certain molds are associated with bird waste and are of concern for immune-compromised individuals. Other diseases of the respiratory tract may also result from chronic exposure to bird waste. Exposure to bird wastes are thought to be associated with the development of hypersensitivity pneumonitis in some individuals. Psittacosis (bird fancier's disease) is another condition closely associated with exposure to bird wastes in either the occupational or bird raising setting. While immune-compromised individuals have an increased risk of health impacts following exposure to the materials in bird wastes, these impacts may also occur in healthy individuals exposed to these materials.

The methods to be employed in clean up of a bird waste problem depend on the amount of waste and the types of materials contaminated. The MDPH has been involved in several indoor air investigations where bird waste has accumulated within ventilation ductwork (MDPH, 1999). Accumulation of bird wastes have required the clean-up of such buildings by a professional cleaning contractor. In less severe cases, the cleaning of the contaminated material with a solution of sodium hypochlorite has been an effective disinfectant (CDC, 1998). Disinfection of non-porous materials can be readily accomplished with this material. Porous materials contaminated with bird waste should be examined by a professional restoration contractor to determine if the material is salvageable. Where a porous material has been colonized with mold, it is recommended that the material be discarded (ACGIH, 1989).

The protection of both the cleaner and other occupants present in the building must be considered as part of the overall remedial plan. Where cleaning solutions are to be used, the "cleaner" is required to be trained in the use of personal protective methods and equipment (to prevent either the spread of disease from the bird wastes and/or exposure to cleaning chemicals). In addition, the method used to clean up bird waste may result in the aerosolization of particulates that can spread to occupied areas via openings (doors, etc.) or by the ventilation system. Methods to prevent the spread of bird waste particulates to occupied areas or into ventilation ducts must be employed. In these instances, the result can be similar to the spread of renovation-generated dusts and odors in occupied areas. To prevent this, the cleaner should employ the methods listed in the SMACNA Guidelines for Containment of Renovation in Occupied Buildings (SMACNA, 1995).

General Environmental Pollutants

Accumulated chalk dust was noted in several classrooms. Chalk dust is a fine particulate, which can become easily aerosolized and serve as a source of eye and respiratory irritation. A number of classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999). Cleaning products were found on floors, counter-tops and beneath sinks in a number of classrooms. Cleaning products and dry erase board markers and cleaners contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals.

Univents are equipped with filters that strain particulates from airflow. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by the unit by increased resistance (called pressure drop). Prior to any increase of filtration, each univent should be evaluated by a ventilation engineer to ascertain whether they can maintain function with more efficient filters. The age and function of univents may preclude any attempt to increase filter efficiency.

Wall cracks and utility holes were observed in a number of areas. Several areas in the school were missing ceiling tiles. Wall cracks, utility holes and missing ceiling tiles can provide pathways for the movement of drafts, dusts and particulate matter between rooms and floors.

A number of classrooms contained upholstered furniture. Upholstered furniture is covered with fabric that comes in contact with human skin. This type of contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. In addition, if relative humidity levels increase above 60 percent, dust mites tend to proliferate (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, M.A., 1994). It is also recommended that upholstered furniture (if present in schools), be professionally cleaned on an annual basis or every six months if dusty conditions exist outdoors (IICR, 2000).

Also of note was the amount of materials stored inside classrooms. Items were seen piled on windowsills, tabletops, counters, bookcases and desks in classrooms throughout the school. The large amount of items stored allows for dusts and dirt to accumulate. These stored items, (e.g. papers, folders, boxes) make it difficult for custodial staff to clean. Dirt and dust accumulation was also noted in the interiors of univents. When activated, this material can become aerosolized by the univents. Dust can be irritating to the eyes, nose and respiratory tract.

Ground floor areas are equipped with floor drains (see Picture 18). Areas such as the wood shop and other areas have drains that did not appear to have recently drained water, which can lead to dry traps. A trap forms an airtight seal when water is poured down the drain. A dry trap can allow for sewer gas to back up into the building. Sewer gas can be irritating to the eyes, nose and throat.

A number of classrooms contained window-mounted air conditioners (WAC). These units are normally equipped with filters, which should be cleaned or changed as per the manufacturer's instructions to avoid the build-up and re-aerosolization of dirt, dust and particulate matter. Filters in several of the WACs were examined and found to be occluded with dirt and debris. The WAC in room 215 was missing its filter and appeared to have microbial growth inside, which can be aerosolized when the unit is activated.

Conclusions/Recommendations

The solution to the indoor air quality problem at the Auburn High School requires attention in several areas. The combination of the general conditions, configuration of the ventilation system, the modification of space, condition of HVAC equipment and the limited availability of replacement parts, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality in the building. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required, consisting of more immediate **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns. In view of the findings at the time of this visit, the following recommendations are made:

The following **short-term** measures should be considered for immediate implementation:

1. Replace bunghole caps on all flameproof cabinets throughout the building. Remove vent hose and reseal wall/window penetrations.
2. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
3. To maximize air exchange, the BEHA recommends that the ventilation system operate continuously during periods of school occupancy, independent of classroom thermostat control.
4. Remove all blockages from univents and exhaust vents to ensure adequate airflow. Clean out interiors of univents regularly.
5. Implement the corrective actions recommended concerning remediation of bird wastes. Remove bird's nests from the exhaust vents. Repair these exhaust fans to working order. Examine the feasibility of installing fans in a configuration to reduce vandalism of this equipment.
6. Examine mechanical exhaust vents building-wide for function and activate if operable.
7. Install switches that allow for adjustment of chemistry lab exhaust vents fan speed.
8. Repair the exhaust vent for the chemical storage area.
9. To regulate airflow in classrooms without functioning ventilation systems, use openable windows to control for comfort. Care should be taken to ensure

windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.

10. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed in univents. Ensure that installed filters are of a proper size and installed in a manner to eliminate particle bypass of the filter. Note that increased filtration can reduce airflow produced by increased resistance. Prior to any increase of filtration, each unit should be evaluated by a ventilation engineer as to whether they can maintain function with more efficient filters.
11. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
12. Increase cleaning of wood dust from wood shop surfaces. This can include the use of a vacuum cleaner equipped with a high efficiency particle arrestance (HEPA) filter to remove wood dust from the grooves and seams of floor blocks.
13. Consider relocating the printers in the print shop underneath the metal fume hood to provide exhaust ventilation. If metal fume hood is not operational, repair.
14. Clean and maintain aquariums to prevent bacterial/microbial growth.

15. Move plants away from univents in classrooms. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Consider reducing the number of plants in certain areas.
16. Have an experienced hazardous waste removal consultant evaluate the chemical storeroom for proper chemical storage and recommendations for removal of hazardous waste.
17. Have a chemical inventory done in all storage areas and classrooms. Discard hazardous materials or empty containers of hazardous materials in a manner consistent with environmental statutes and regulations. Follow proper procedures for storing and securing hazardous materials. Obtain Material Safety Data Sheets (MSDS') for chemicals from manufacturers or suppliers.
18. Maintain these MSDS' and train individuals in the science department in the proper use, storage and protective measures for each material in a manner consistent with the Massachusetts Right-To-Know Law, M.G.L. c. 111F (MGL, 1983).
19. Properly store chemicals and cleaning products.
20. Seal holes, repair wall cracks and replace missing ceiling tiles to prevent egress of odors, fumes and vapors between rooms and floors.
21. Clean chalk boards and chalk trays regularly to prevent the build-up of excessive chalk dust.
22. Clean upholstered furniture on the schedule recommended in this report. If not possible/practical, remove upholstered furniture from classrooms.

23. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

24. Ensure all window-mounted air conditioners are equipped with filters; change filters as per the manufacturer's instructions to prevent the re-aerosolization of dirt, dust and particulate matter.

The following **long-term** measures should be considered:

1. Based on the age, physical deterioration and availability of parts of the HVAC system, the BEHA strongly recommends that an HVAC engineering firm fully evaluate the ventilation system. This evaluation must include an examination of the integrity of fiberglass lined ductwork as well as the modifications of the former lab area (A-321, A 322 & A-323).

2. Continue to isolate and repair water leaks. Repair/replace any water-damaged ceiling tiles, plaster and/or other damaged building materials. Examine above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial. Building occupants should report any roof leaks or other signs of water penetration to school maintenance staff for prompt remediation.

3. Examine the feasibility of providing exhaust ventilation for the wood shop dust collector.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

ASHRAE. 1989. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 62-1989.

ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.

Berry, M.A. 1994. *Protecting the Built Environment: Cleaning for Health,* Michael A. Berry, Chapel Hill, NC.

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL.

CDC. 1998. Compendium of Measures to Control Chlamydia psittaci Infection Among Humans (Psittacosis) and Pet Birds (Avian Chlamydiosis), 1998. *MMWR 47:RR-10. July 10, 1998.*

IICR. 2000. IICR S001 Reference Guideline for Professional On-Location Cleaning of Textile Floor Covering Materials Institute of Inspection, Cleaning and Restoration Certification. Institute of Inspection Cleaning and Restoration, Vancouver, WA.

MDPH. 1999. Indoor Air Quality Assessment Norfolk Probate Court, Dedham, Massachusetts. Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Boston, MA.

MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. MidAtlantic Environmental Hygiene Resource Center, Philadelphia, PA.

MGL. 1983. Hazardous Substances Disclosure by Employers. Massachusetts General Laws. M.G.L. c. 111F.

NFPA. 1996. Flammable and Combustible Liquids Code. 1996 ed. National Fire Protection Association, Quincy, MA. NFPA 30.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0.

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

SMACNA. 1995. IAQ Guidelines for Occupied Buildings Under Construction. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

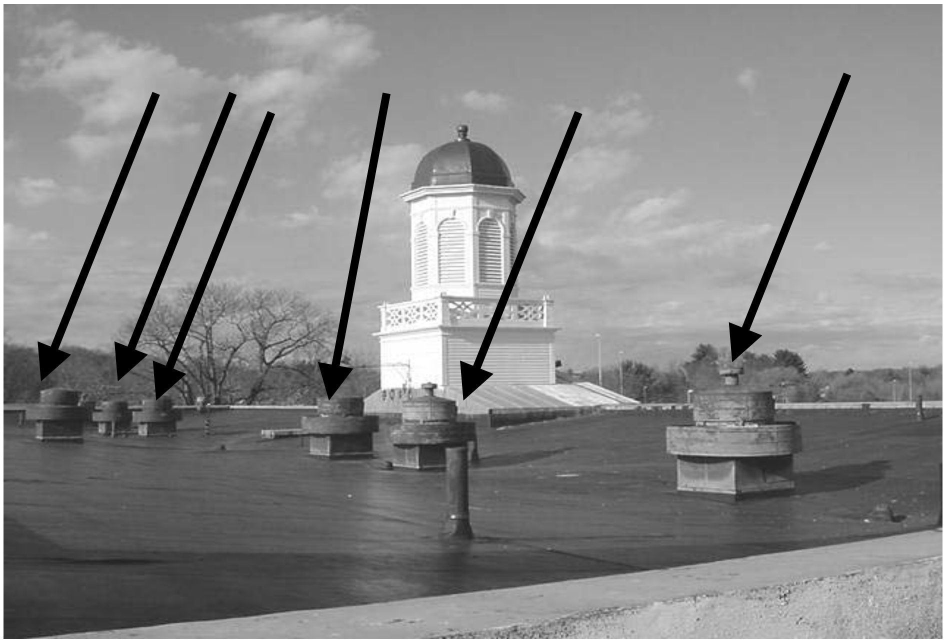
Thornburg, D. 2000. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.

US EPA. 1992. Indoor Biological Pollutants. US Environmental Protection Agency, Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Research Triangle Park, NC. ECAO-R-0315. January 1992.

Picture 1

Example of Classroom Univent

Picture 2



Rooftop Exhaust Vents

Picture 3

Deactivated Exhaust Vent in West Wall of Building

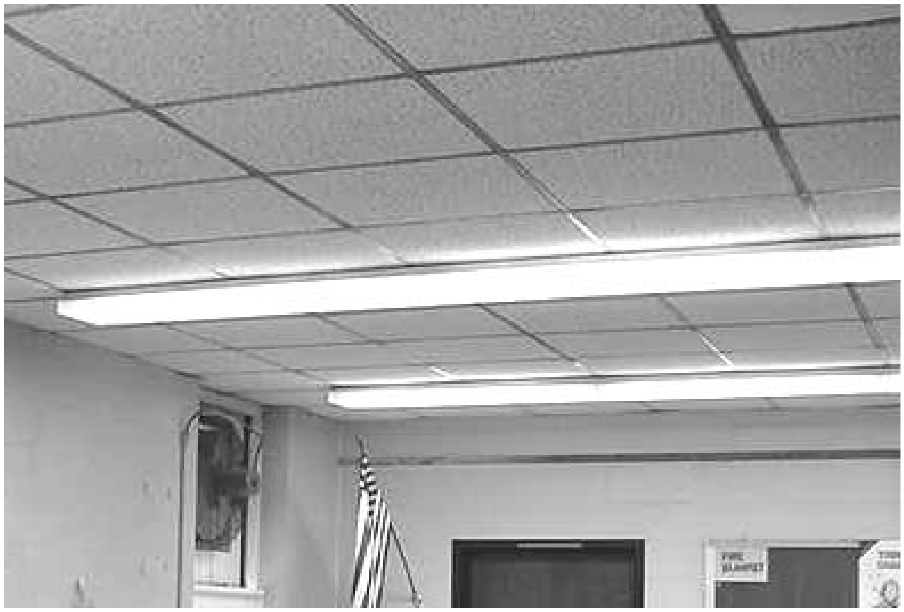
Picture 4

Water-Damaged Wall/Ceiling Plaster

Picture 5

Shrubbery and Flowering Plants in Contact with Exterior Walls

Picture 6

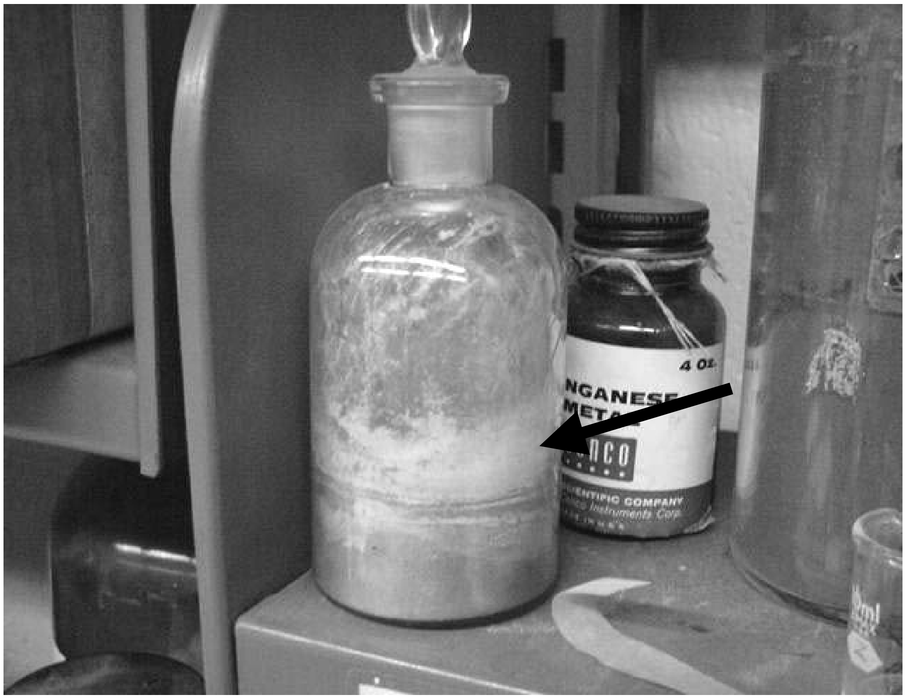


Exhaust Fan in Chemistry Lab

Picture 7

Flameproof Cabinet with Open Bung Hole

Picture 8



Unlabelled Container of Elemental Mercury (Approximately 10 Lbs.), Stored on an Open Shelf

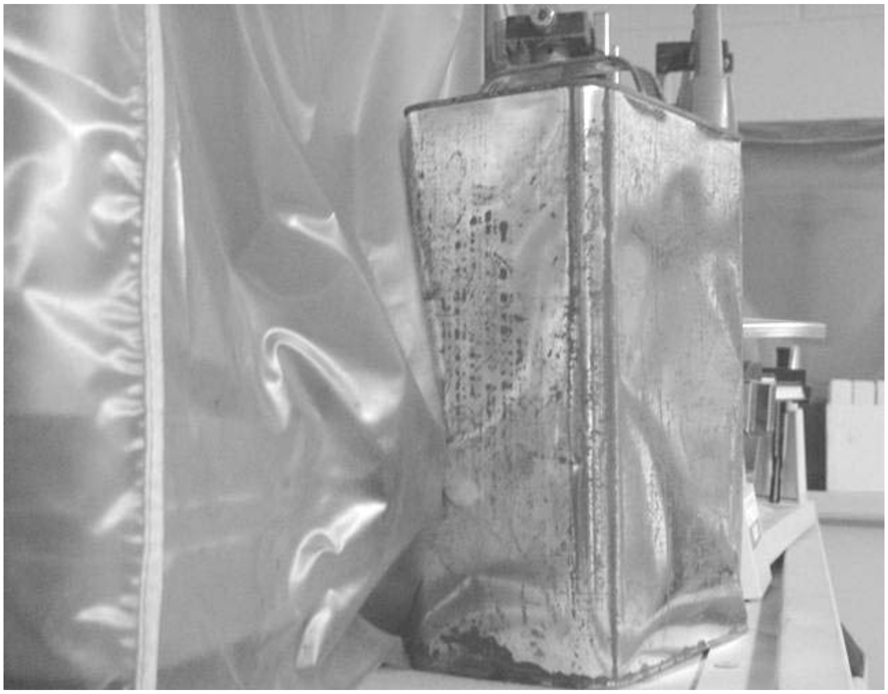
Picture 9

Two Corroded Containers of Phosphorous Stored on an Open Shelf

Picture 10

A Box that Appears to be Chemically Damaged

Picture 11



A Container of Carbon Tetrachloride Adhered to Plastic Sheeting

Picture 12

Container of Leaking Phenylhydrazine Base

Picture 13

Materials Stored in a Plain Metal Cabinet in the Wood Shop

Picture 14

Wood Dust Collector - Not Ducted to the Outdoors - Is Allowed to Exhaust into the Room

Picture 15

Metal Fume Exhaust Hood in Print Shop

Picture 16

Flameproof Cabinet - Duct Connected to the Exterior Wall of the Building

Picture 16A

Terminus of Vent for Print Shop Flame-Proof Cabinet

Picture 17

Bird Wastes Inside Exhaust Vent, Along the West Exterior Wall of the Building

Picture 18

Floor Drain in Wood Shop

TABLE 1

Indoor Air Test Results – Auburn High School, Auburn, MA – December 20, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Outside (Background)	421	52	30					CO=2 ppm, rear building-11:20am Cloudy
Main Office	700	72	33	2	Yes			Window mounted A/C, ~6 plants, window open, CO=3
Room 220	1323	74	33	0	Yes		Yes	Window slightly open, no draw from exhaust vent, chalk dust
Room 208	992	73	33	10	Yes	Yes	Yes	Univent off, no draw from exhaust, window and door open, CO=2
Room 206	982	72	33	20	Yes	Yes	Yes	Univent off-accumulated debris inside, 5 plants, door open
Room 204	941	72	34	14	Yes	Yes	Yes	Univent off-accumulated debris inside, window open, chalk dust, plant, personal fan
Room 202	858	72	32	5	Yes	Yes	Yes	Water-damaged ceiling plaster, dry erase board, door open
Room 222 (Math Help)	861	73	31	3	Yes	No	No	Water-damaged ceiling plaster-above window, holes in wallboard, door open
Room 203	990	73	33	21	Yes	Yes	Yes	Univent off-debris, exhaust obstructed by trash can, window mounted A/C, ~22 computers, water-damaged ceiling plaster, dry erase board, window open
Room 205	1350	72	34	15	Yes	Yes	Yes	Univent off, water-damaged ceiling plaster, chalk dust

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Auburn High School, Auburn, MA – December 20, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 100	823	73	32	7	Yes			Partial carpet, refrigerator on carpet, 2 sinks, elec. stove/dryer-both vented out window, dry erase board
Room 103	1395	74	35	16	Yes	Yes	Yes	Univent off-reportedly gives heat only, water-damaged ceiling plaster over window, dry erase board
Room 105	1322	75	35	20	Yes	Yes	Yes	Univent off, accumulated dirt/debris in exhaust vent, window open, dry erase board, water-damaged ceiling plaster over window, CO=2
Room 107	633	70	30	0	Yes	Yes	Yes	Univent off, window open, dry erase board
Room 109	1656	73	37	23	Yes	Yes	Yes	Univent and exhaust off, window and door open, dry erase board
Room 114	1413	73	36	0	Yes	Yes	Yes	Window open, upholstered furniture, area carpet
Room 12	1100	68	41	0	Yes	Yes	Yes	Univent and exhaust off, utility holes
Room 10	1532	71	41	20	Yes	Yes	Yes	Univent and exhaust off, water-damaged ceiling plaster around pipe, utility holes, chalk dust
Room 8	1215	72	37	6	Yes	Yes	Yes	Supply and exhaust off, 5 gas stoves, area rugs, oven cleaner/drain cleaner under sink

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results – Auburn High School, Auburn, MA – December 20, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Room 6 (Art room)	718	75	29	10	Yes	Yes		Ceiling mounted univent-off, utility holes
Art Room Office	824	76	29	0	No	No	Yes	Carpet, utility holes, storage of accumulated items
Art Storage Room					No		No	Passive door vent, accumulated items/dust, varnish-very old, oxidizers/flammables stored on wooden shelves, lead containing glazes
Kiln Room							Yes	Gas kiln, exhaust hood vented into chimney, exterior door
Teachers' Lunchroom	595	76	27	3	No			Wall mounted A/C
Cafeteria	1074	73	30	0	Yes	Yes	Yes	8 ceiling fans, ~300 occupants gone 5 min., 4 vending machines, exterior door
Auditorium	494	69	28	0	Yes	Yes	Yes	Ventilation off
Main Office-Work Area	659	72	31	1	No	No	No	2 photocopiers, 2 laminators, carpet, door open
Mrs. Carpenter's Office	629	73	29	0	Yes	No	No	Window mounted A/C, 3 plants, carpet, door open
Mr. Zanghi's Office	683	72	29	1	Yes	No	No	Carpet, plant, door open, exhaust odors reported, window had reportedly been open until just prior to testing

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 4

Indoor Air Test Results – Auburn High School, Auburn, MA – December 20, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Guidance Office	661	74	29	3	No	No	No	2 ceiling fans, carpet, door open
Room 221	1778	73	36	22	Yes	Yes	Yes	Univent off, no draw from exhaust-broken pull chain/flue, window open, 2 plants
Room 219	1323	72	33	0	Yes	Yes	Yes	Univent off-items on top, raw from exhaust-slight back draft-accumulated dirt/dust in vent-broken pull chain, door open
Room 217	1425	72	34	0	Yes	Yes	Yes	Univent off, exhaust obstructed by bookcase, door open
Room 215	1255	73	35	9	Yes	Yes	Yes	Univent off, window mounted A/C-no filter/mold growth/accumulated dust & debris, chalk dust, door open
Room 213	1014	73	32	8	Yes	Yes	Yes	Univent off, chalk dust
Room 211	915	71	33	4	Yes	Yes	Yes	Items on univent, tree in large planter, efflorescence/water-damaged ceiling-peeling paint, door open
Room 209	1250	71	34	20	Yes	Yes	Yes	Univent off
Room 207	954	71	32	21	Yes	Yes	Yes	Univent off, abandoned exhaust?

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Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 5

Indoor Air Test Results – Auburn High School, Auburn, MA – December 20, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Room 102	1032	72	34	15	Yes	Yes	Yes	Univent off, no draw from exhaust-garbage in vent/back draft, window and door open
Room 112	964	72	31	0	Yes	Yes	Yes	Univent off, no draw from exhaust-back draft, chalk dust, door open
Room 114	1600	73	38	2	Yes	Yes	Yes	18 occupants gone <5 min., water-damaged ceiling/efflorescence along top of window frame, no draw from exhaust, chalk dust
Room 113	2166	73	40	23	Yes	Yes	Yes	Severe water damage on ceiling-efflorescence-reportedly from univent leaks, accumulated items on univent, chalk dust
Room 5 (Chorus room)	796	74	31	13	Yes	Yes	Yes	Univent off
Satellite Early Childhood Program	1032	75	32	28	Yes	Yes	Yes	Kindergarten aged occupants, passive supply, wall mounted exhaust, heat/humidity complaints, accumulated dust on surfaces, 2 water-damaged CT, window open
Gym	923	71	30	10	No	Yes	Yes	Ventilation off
Library	490	70	27	2	Yes	Yes	Yes	Hanging plants over carpet, 4 univents-off, exhaust deactivated, water-damaged CT, accumulated dust, dust complaints

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Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

TABLE 6

Indoor Air Test Results – Auburn High School, Auburn, MA – December 20, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Room 212	1318	72	34	20	Yes	Yes	Yes	Supply off, 2 ajar CT, whiteboard, chalk dust, wall crack, door open
Room 210	1650	74	37	20	Yes	Yes	Yes	Univent and exhaust off
Room 214 (Chemistry Lab)	1196	73	35	12	Yes	Yes	Yes	Univent and exhaust off, chem. hood-off, window exhaust fan-off, window open, 6 water-damaged CT
Room 216 (Chemistry Lab)	1431	72	38	14	Yes	Yes	Yes	Univent and exhaust off, chem. hood off, window exhaust fan-off, plants
	1179	72	32	0	Yes	No	No	Crack-elevator
Room 106	1402	77	36	27	Yes	Yes	Yes	Window mounted A/C-filter dirty, 4 water-damaged CT, chalk dust, door open
Room 104	1771	72	36	11	Yes	Yes	Yes	2 window mounted A/C-dirty filters, water-damaged CT, door open
Room 110	946	67	33	7	Yes	Yes	Yes	Univent off, 2 window mounted A/C-dirty filters, chalk dust, door open
Room 108	1429	71	37	24	Yes	Yes	Yes	Univent off, fish tanks-algae, chalk dust, door open
Gym	795	70	31	12	No	Yes	Yes	
Cafeteria	892	71	37	200+	Yes	Yes	Yes	

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CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 7

Indoor Air Test Results – Auburn High School, Auburn, MA – December 20, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
School Store	788	69	32	4	Yes	Yes	Yes	Supply off
Gym	686	66	32	60+	No	Yes	Yes	Supply off-damaged
Woodshop	729	67	34	15	Yes	Yes	Yes	Supply off
Small Engine/Printing	497	70	30	4	Yes	Yes	Yes	Supply off, door open, darkroom
Room 2	531	69	30	0	Yes	No	No	2 missing CT
Room 1	448	67	31	0	Yes	Yes	Yes	Supply and exhaust off, water in window

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Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Table 8
Survey of Exhaust Vents on Roof of Auburn High School

Labeled Exhaust Vents Found Operating	Labeled Exhaust Vents Found Deactivated
4L220	J1N
4L220 Boys Restroom	7
4	6
23	14
24	1
13	12
21	11
20	19
18	
Total Number Operating: 9*	**Total Number Deactivated: 15***

*totals include unlabeled exhaust vents examined in the roof

Table 9
Chemicals Stored with the Chemical Storage Closet

Chemical	Quantity
1-pentanol	1 pint
5- cyclohexanol	500 gm
acetic anhydride	1 bottle
amyl acetate	1 pint
butanol	1 pint
carbon tetrachloride	4 liters
cyclohexane	500 ml
cyclohexanol	500 gm
dimethylaniline	4 oz
ethyl alcohol	10 gallons
heptane	1 pint
mercury	1 glass jar
methanol	1 gallon
octanol	1 quart
phenol	¼ lb.
phosphorous	2 containers
resorcinol	150 gm
sodium	1 container
tetrachloroethane	1 pint
Thermit	1 lb